Development of Pre-Molded Joint for 230kV XLPE Power Cable

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Abstract : Traditionally, Various cable joints including TMJ(Tape Molded Joint), TJ(Tape Wrapped Joint) and PJ(Prefabricated Joint) have been developed and used for XLPE cable. But Pre-molded joints that have significant advantages as less skill, less jointing time and quality control have been widely used lately. We already developed pre-molded joint for 154kV-class in 2004. Under the experience and technology, we succeeded development of pre-molded joint using silicone rubber for 230kV class and passed IEC type test in accordance with IEC standard 62067. All the tests were carried out successfully and proved that the new PMJ has quite high reliability for 230kV class XLPE cable.

Keyword : Silicone Rubber, 230kV, EHV XLPE cable, Pre-molded Joint

1. Introduction

Because of the growing of popularity in worldwide market of straight through joints for EHV XLPE cables in a wide range of voltage class recently, we have developed pre-molded joints up to 230kV voltage class with research on electrical and mechanical properties of material.
Pre-molded joints which are prefabricated and tested electrically in the manufacturing site have high quality reliability. For electrical test on the pre-molded rubber unit, we also have developed electrical test facilities. We have carried out routine test on the pre-molded joints at 2.5Uo/30min for AC withstand voltage and 1.5Uo for PD test.[4]
Silicone rubber has several advantages in mechanical and electrical properties in comparison with Ethylene-Propylene Rubber(EPR) as lower elasticity, lower permanent set and so on. And most manufactures of EHV cable joints are using silicone rubber for the pre-molded unit. So we adopted silicone rubber as insulation and electrode materials and studied mechanical and electrical properties of silicone rubber to apply it to our design prototype of pre-molded rubber unit.
We researched rubber injection process and curing process for silicone rubber with injection and curing analysis computer module. In this process, we found out expected defects like air gap, excoriation and so on in the pre-molded rubber unit and then revised the injection process and the curing condition to resolve the expected defects.
We studied the installation process for easier installation and shorter installation time and research inner mechanical stress and inner strains during installation with mechanical stress analysis module. When the rubber unit is installed on the cable, the interfacial pressure between rubber unit and cable insulation is very important parameter to guarantee electrical performance, so we studied the interfacial pressure properties using interfacial pressure analysis units developed by ourselves. The interfacial pressure analysis units consist of steel pipe to simulate outer diameter of the cable insulation, embedded pressure gauges and pressure analysis PC module.[3] As the result of mechanical analysis, we found that one pre-molded rubber unit is applicable to various cable sizes. (from 115% to 145% in expansion rate)
The electrical properties of the pre-molded joint are satisfied our target test voltage. We carried out AC withstand test, AC breakdown test and lightning Impulse withstand test and lightning impulse breakdown test several times. And we established the electrical design standard of silicone rubber unit.
This paper reports on the electrical and mechanical properties of silicone rubber unit, electrical characteristics of the pre-molded joint and type test result in accordance with IEC 62067.

2. Mechanical test on silicone rubber

Now, EPR and silicone rubber are mainly applied to pre-molded joints for the EHV underground cable. We adopted silicone rubber as insulation and electrode materials because silicone rubber was known to have several advantages in mechanical and electrical properties.
We studied the mechanical characteristics of insulation silicone rubber and semi-conductive silicone rubber, the research item consists of tensile strength, tear strength, permanent set and so on.
The result shows excellent mechanical properties of permanent set and elongation in comparison with EPR. See table 1.

Table 1. Material properties of silicone rubber

Item	insulation	conductive
Tensile strength [N/㎟]	4.0	6.0
Stiffness [Shore A]	40	40
Elongation at break [%]	500	650
Tear strength [N/㎜]	25	12

During insertion of pre-molded unit onto the cable, there are possibilities of occurrence of excoriation at the interface between insulation and conductive electrode. It could affect the degradation electrically. So we tested the adhesive property of silicone rubber that we adopted. The result is that the adhesive property between insulation and conductive material has excellent adhesive property. All ten test samples were torn at the insulation portion, not the interface. See figure 1.